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Scaffolding Online Discourse in Collaborative Ill-Structured Problem-Solving for Innovation

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Abstract. This work highlights the importance of verbal creativity, providing a productive online discourse definition, in which students intertwine convergent and divergent thinking by means of a transactional and controversial dialog. Developing the formulated productive online discourse definition, it is also presented and evaluated, an original scaffolding process designed here to further collaborative knowledge building, during ill-structured problem-solving, focusing on creativity and innovation. Evidence from qualitative online discourse analysis indicated an improvement in the knowledge building processes, and knowledge advancement and deepening after teacher's scaffolding.

Keywords: scaffolding, creativity, collaboration, Ill-structured problem-solving, innovation, productive online discourse, transaction.

1. Introduction

Computer supported collaborative learning has often been described as creative processes. In collaborative learning, learners should transcend their past experiences and not merely demonstrate knowledge but rather put themselves in a position to extend their knowledge. The knowledge building concept (Bereiter and Scardamalia, 2003) is related to a progressive discourse, where there is knowledge co-construction and advancement as well as the achievement of a deeper knowledge in collaborative settings. But, the knowledge building does not occur whenever learners interact.

When students engage themselves in a group discussion it is not necessarily productive. There are significant differences between a discussion that promotes knowledge creation and a simple discussion. King (1999) noticed that students do not always engage themselves in high level discourse unless they are prompted to do so.

Studies (Lipponen *et al.*, 2001; Jakobson, 2006) suggest that students in computer supported collaborative learning environments are not always active participants. Collab-

orations, which are not carefully prepared, result in superficial and unreflective products in most cases. The competence to use collaboration as a learning tool is not a quality that the participants automatically possess when they are asked to participate in online education (Amhag and Jakobsson, 2009).

The ability to collaborate should be understood as a collective competence that a group of participants must achieve when they are collectively engaged in an online course. The teacher must therefore help the students to develop the collective ability to use dialogues for learning. There is evidence that teaching learners how to collaborate, and in particular how to work together to create meaning, is a part of the process of learning collaboratively which can enhance outcomes further (Nussbaum *et al.*, 2009).

Enhancement of creativity and cognitive facilitation of collaborative ill-structured problem-solving are difficult tasks, but not impossible. Research carried out in recent decades has shown that is possible to mediate thinking; that is, significant changes in a human being's cognitive functioning can be achieved after intervention (Lizarraga, *et al.*, 2009). To mediate thinking through discourse, the teacher must know underlying knowledge building processes. However, knowledge building theory has not fully been analyzed or taken account of the social and cultural transformations involved in knowledge advancement. Scardamalia and Bereiter's characterize knowledge building as a dynamic system where ideas interacting with ideas lead the generation of new ideas. This characterization appears, to some extent, to be tautological in nature (Hakkarainen, 2009). In order to provide a better explanation it is necessary to expand the scope of the knowledge building theory.

2. Purpose of the Study

The main goal of this work was to develop an original scaffolding process to promote productive argumentation. In order to achieve this objective it was necessary to broaden the perspective of how the knowledge advancement occurs during ill-structured problem solving and also to investigate the relation between argumentation and knowledge creation. Three main learner obstacles that motivated research investigations were: failure to deeply engage the knowledge, failure to generate alternative ideas, and failure to compare different ideas towards an innovative solution. The research questions of this work, contextualized in ill-structured problem solving situations, are:

- How can teachers scaffold students to promote collaborative knowledge creation?
- How collective knowledge creation emerges from collaboration?
- What is the relationship between online dialogue and collaborative knowledge creation?

3. Metacognitive and Cognitive Requirements of Ill-Structured Problem-Solving

When solving ill-structured problems collaboratively, the validity of a particular point must be investigated, as well as its usefulness in producing new arrangements or patterns (Jonassen, 1997). For example, a number of hypotheses for the potential causes of

a problem can be established and judgment on each of them must be performed considering its validity and comparative analysis. Students pursue originality in a situation in which the knowledge is multi-layered, socially negotiated, and continuously subject to re-evaluations. In this sense, the education is for innovation, where solutions are not previously known and there can be more than one correct solution. Students pursue deeper knowledge, and innovative solution.

Ill-structured problem-solving is directly correlated to creative thinking in real world, requires developing cogent arguments to support divergent thinking and reflective judgment. Engages not only cognition and meta-cognition of the processes used to solve the problem, but also epistemic cognition of the epistemic nature of the process and the truth or value of different solutions (Kitchner, 1983). Ill-structured problems are controversial and evoke dialectical aspects of reasoning (Saye and Brush, 2002). The learner must enter in a productive discourse to deeply engage the knowledge. The students must move beyond sophisticated reasoning to dialectical reasoning that genuinely recognizes alternative perspectives regarding ill-structured problems (Parker *et al.*, 1989). Alternative ideas must be generated and compared. Students must assume an evaluative view that assertions may be compared and judged by the quality of evidence and reasoning used to support them (Saye and Brush, 2002).

A well-structured problem solving has a clear initial goal state, a known goal state, a constrained set of rules to achieve the solution, and optimal solution path. In contrast, aspects of an ill-structured problem are not cleared described, and the information to solve the problem is not entirely contained in the problem statement. Thus, is not obvious what to do to solve it and a reasonable solution is one that takes into consideration opposing views. Jonassen (2001) identified two kinds of ill-structured problems: case analysis and design. In case analysis, students deals with solution identification, alternative actions, and argumentation, while in design students are supposed to act on goals to produce artifact, and structure and articulate the problem.

In this work, we investigate the effect of scaffolding argumentation during ill-structured problem solving. The scaffolding concept has been originally defined by Bruner (1978) as cognitive support given by a more capable peer that enables the students to perform tasks they would not be able to perform by themselves. The scaffolding concept has its theoretical foundations in the Vygotsky's (1978) zone of proximal development. The zone of proximal development was defined by Vygotsky as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

At present time, scaffolds appear in different forms (Palinscar and Brown, 1984; Schoenfeld, 1985; Scardamalia *et al.*, 1989). For example, the scaffolding concept has been re-conceptualized to embrace more symmetrical kind of collaboration, in which students scaffold each other (Fernándes *et al.*, 2001). Most scaffolding techniques can be classified as either soft or hard scaffolds (Simons and Klein, 2007). Soft scaffolds are dynamic and refer to the teacher's actions in support of learners' efforts at the moment of when a learner has a specific need. On the other hand, hard scaffolds are static sup-

ports that can be developed in advance based on anticipated or typical learner difficulties associated with a task.

Researchers found that solving an ill-structured problem requires regulation of cognition. According to Ge and Land (2004), metacognitive scaffolding is an indirect way to scaffold cognition. Metacognitive awareness implies the recognition of areas of limited understanding, adopting working hypotheses, asking questions, monitoring thinking, and revisiting early interpretations. King (1991) emphasized the role of questions prompts in symmetrically scaffolding metacognition, by means of an externalized support during problem solving accomplish through guided student-generated questioning. Scaffolding strategies such as guiding students to self generate questions may promote comprehension, monitor cognitive thinking, and facilitate reflexive thinking ill-structured problem-solving (Demetriadis, 2008).

Ill-structured problem-solving demands complex learning skills, including the use of meta-cognition and argumentation. The metacognitive scaffolding process developed in this research is hard and symmetrical. It takes into consideration the role of divergent and convergent thinking in knowledge building during ill-structured problem-solving. Jonassen (1997) showed that solving ill-structured problem opens the possibility for the generation of different solutions. Ill-structured problem-solving requires the production of more extensive arguments and evaluation criteria in support to their solutions than traditional well-structured problems, due to the fact the students have to support alternative solutions, as well as to find the best solution from among many. Comparative analysis of the solutions is strongly related to convergent thinking, while the creation of alternative solutions and divergent thinking are directly correlated. On the other hand, the production of deeper arguments and ideas must emerge either in comparative analysis or in the recognition of alternative views and involves both convergent and divergent thinking.

Guilford (1967) identified two distinct forms of thinking: divergent and convergent thinking. Convergent production is in the area of logical deduction to determine unique answer. Divergent production is defined as the generation of information from given information, where the emphasis is upon variety and quantity of output from the same source. In divergent production the logical possibilities from given information are generated, whereas in convergent production logical necessities are generated. Divergent thinking requires flexibility and fluency of thinking, and demands readiness to change direction and modify information. It means having a variety of perspectives, and making unusual associations. On the other hand, convergent thinking typically involves bringing material from a variety of sources to bear on a problem and apply a systematic approach to solve the problem. Convergent thinking embraces evaluation, description, observation, deduction and prioritization in relation to a given problem. This is an analytical thinking which focuses on essential details, selection of ideas according to their relevance and simplifies problems considering the most significant details.

4. Productive Online Discourse in Literature

Studies have provided ample evidence that the quality of talk has strong impact on the quality of learning (Mercer and Littleton, 2007). This work agrees with a historic-cultural

point of view (Vygotsky, 1978), considering discussions a way for participants to share their experiences and interpretations, together negotiating knowledge and understanding. Through dialog, new conceptions are collectively constructed.

Although, many aspects of online discussion as it relates to learning remain understudied at this point of time (Dennen, 2008), the most creative collaborative situation is transactional. A transactional situation is characterized by complementarities in participants' talk and by inclusive utilization of each other's view (Eteläpelto and Lahti, 2008).

Many authors have approached a productive argumentation as transactional (Koschmann, 2003; King, 1998; Clark *et al.*, 2007; Johnson and Johnson, 1987; Saye and Brush, 2002). King (1998) elaborated an inquiry-based model of mutual peer tutoring in which tutoring partners mediate each others' learning in a transactional manner. In a transactional cognitive partnership, partner's comments, questions and responses are dependent on those of other partner. Any move by one partner is dependent on others' partner current understanding and response.

Besides transactional feature, controversy plays an important role in discussions. Toulmin (1958) defined the term rebuttal as the exceptional conditions which might be capable of defeating or rebutting the warrant conclusion. Erduran *et al.* (2004) refined Toulmin's definition of rebuttal to focus exclusively on challenges to the grounds of a claim. They addressed the quality of an argument in function of the number of rebuttals. The quality is better when extended arguments have more than one rebuttal.

5. The Study

In this research, the philosophy of John Dewey is addressed to better reveal knowledge building processes and productive discourse when solving ill-structured problems collaboratively. Dewey's knowledge creation point of view makes available a controversial and transactional perspective of how the knowledge advancement and deepening occur during ill-structured problem-solving and also reinforces the relation between argumentation and knowledge creation. According to Dewey (1972) experience is the transaction between individual and environment. It is the continuous and mutual formation of the two and, as such, experience is both a process and a product (Elkjaer, 2004). The term transaction emphasizes the transformative aspects of interaction. Dewey (1929) has given a specific name to such a mutual exchange whenever a response to another's act involves contemporaneous response to a thing as entering into other's behavior, and this upon both sides.

Dewey defined inquiry as the set of operations by which an indeterminate situation is resolved, settled, or rendered determinate. Based on Dewey's philosophy of education and focusing on the concept of inquiry and the concept of transaction, it is proposed here a knowledge building cycle described following:

1. Joint and individual concrete and symbolic experience implies reflections, thinking in action occurs.
2. Reflections cause interpretations and re-interpretations, resuming a transaction.

3. Interpretations and re-interpretations can involve uncertainty or clear interpretations at individual level, as well as, divergence of opinions or intersubjectivity at group level.
4. Both uncertainty and divergence of opinions makes continuity in transaction.

In Dewey's transactional theory of knowledge, the knowledge is a developed habit of inquiry, reflection, and problem-solving and a result to attempting to overcome problematic, threatening, and unstable characteristics of shared experience. Experience and thinking are essential to knowledge building, making the students interpretations clear. In this pragmatic view of knowledge, experience is not merely subjective, but concerns transactions with the world. Knowledge building has to do with action and thinking requiring existential operations as well as symbolic operations. The knowledge creation is considered a human mental construction, but a mental construction of our transactions with the world. The recursion in the knowledge building cycle allows the knowledge to advance. The ideas become better at each new interpretations or re-interpretations, which emerge from uncertainty or divergence of opinions.

5.1. *Productive Online Discourse Definition*

Based on Dewey's point of view, we define here a productive online discourse. A productive online discourse is a profitable way of collaboration and a productive argumentation, in which conflicting points of view arise and be turned in new interpretations, discourse is transactional, the rationality of the students operates in function of the rationality of other students, students engage critically, but creatively with each other's ideas, students build knowledge by means of a transactional process that provokes controversy and culminates in a creative synthesis.

5.2. *Scaffolding Online Discourse in Ill-Structured Problem-Solving*

Extending the formulated productive online discourse previously defined, it is presented here an original hard metacognitive scaffolding process that fosters students engage in a productive argumentative process. The scaffolding process privileges a meta-cognitive technique to teach argumentation. In this scaffolding process, the transactional process involves interplay between exploratory and analytical behavior. Two mental activities are integrated: divergent thinking relies on elaboration of different alternatives; convergent thinking depends on a systematic search for solution and multiple evaluative actions. Productive online discourse incorporates and makes explicit the verbal creativity combined with rationality. Productive online discourse is a transactional process that possesses exploratory features, besides critical ones. This scaffolding process promotes a productive online discourse and triggers the knowledge cycle, addressing the reflective process as a range of convergent and divergent mental abilities.

Considering the search for new perspectives, divergence of opinions and uncertainty can facilitate divergent thinking during new discoveries. When students engage critically with each other's ideas, it causes oppositional complementarities that have the potential

to stimulate thoughtful consideration of new and creative ideas. So, the critical thinking, that is a kind of convergent thinking, plays an important role in looking for alternative solution paths and evaluation criteria.

For group creativity occurs, groups must reach consensus on which idea is best, that is convergent thinking. In the search for the best solution, divergence of opinions and uncertainty avoids a premature movement to consensus, thereby increasing the likelihood of creativity. Such a transaction evinces more complexity of thought, elicits reinterpretations, and subsequently leads the group to make better decisions. Thus, the search for new warrants and ideas, that is a kind of divergent thinking, is an essential process to consensus and intersubjectivity.

In order to achieve a deeper and evolutionary knowledge, the knowledge building cycle must recursively occur either when the students are searching for new perspectives or when they are choosing a solution. In an attempt to engage the students in a knowledge building recursive cycle, the scaffolder put the students at the intersection of divergent and convergent thinking during the argumentative process triggered. The scaffolder stimulates the students to intertwine these ways of thinking by means of a transactional and controversial dialog.

5.3. *Method*

A qualitative pre-post case study methodology has been used to confirm the knowledge advancement when a productive online discourse is evoked, thus indicating the efficiency of the scaffolding process. The online discourse has been qualitatively analyzed under Dell Hymes' socio-linguistic viewpoint.

Hymes developed a new area of study evolving a new kind of linguistic, visualizing the language not just as a formal system, but as something culturally shaped in the contexts of social life. Hymes incorporated the concept of speech act in his scheme for the ethnography of communication. According to speech act theory, a minimal unit of human communication is not a sentence but a performance of a particular kind of language acts, such as assertions, declarations, promises, orders, or requests. Apart from a literal meaning, a speech act has its performative meaning that is not what is said but what is done by saying. Hymes proposed to go further than speech acts, defining a nested hierarchy formed by units of analysis. Hymes called the units in this hierarchy: speech situation or communicative situation, communicative event, and speech act. The speech acts are part of a communicative event and communicative events are part of the speech situation. The speech situation describes the context where the communication is immersed.

Considering the interconnection between discourse and thinking expressed in the knowledge building cycle, communicative events can be seen as transactions building up creative collaborative learning processes. Hymes' conceptions about communicative event are evoked here to approach symbolically transactions, describing how thinking in joint actions is depicted in the online discourse. Under this viewpoint, Hymes' sociolinguistic perspective is essential to the comprehension of knowledge building that comes up at online discussions forums dealing with innovations.

5.3.1. *Data Collection, Participants, and Procedure*

Qualitative pre-post case study was repeatedly performed for three years (2007, 2008, and 2009) under the same conditions. In these case studies, qualitatively analyzed asynchronous discussion groups ran during 1 (one month). The students' interaction processes were performed by means of the discussion forum tool available in the Moodle educational environment. The students analyzed were in the fourth year of a computer science under-graduate course (age 21 and 22) and the students were mostly male. Students from one class (approximately 35) were immersed in an ill-structured problem solving activity. They were subdivided in groups composed of 3 to 6 students. Approximately 200 (two hundred) online messages were analyzed each year.

The teacher scaffolded student's discussion and argumentation. Online discussions before and after the scaffolding process were inspected in order to verify student's progress. The study looked at a computer science issue to explore the impact of scaffolding discussions in the failure to deeply engage the knowledge, failure to generate alternative ideas, and failure to compare different ideas towards an innovative solution, during ill-structured problem-solving.

Students were asked to formulate an informal user interface specification. Only two restrictions have been imposed over the user interface: it had to be a graphic user interface, and the interface had to be original. The ill-structured problem has been subdivided in one part related to the generation of possible graphic user interfaces and other part concerning to the comparison and consensus about the best graphic user interface.

5.3.2. *Data Analysis*

Evidence from online observations indicated an improvement in the knowledge building processes after teacher mediation, where many patterns of productive discourse have been found. Before teacher mediation few patterns of productive discourse have been found. The discourse analysis also confirmed the relation between the productive discourse and the knowledge advancement.

The following communicative events and acts exemplifies the importance to diverge before converging and the importance to converge before diverging in a transactional way, revealing some communicative patterns before and after teacher's mediation.

Communicative Acts and Events Analysis in the Generation of Possible Graphic User Interfaces before Teacher's Scaffolding

1. Communicative Event Questioning

   Student 7. "I would like to know what are the advantages of your interface in comparison to Partitionmagic interface."

   Student 9. "I didn't think about the details of my interface yet."

   Student 7 has made a question to student 9, but student 9 has not answered properly. Student 9 has not advanced the knowledge after the intervention of student 7.

2. Communicative Event Attack

   Student 14. "If there is a blackout, how can the user see anything in the computer screen?"

In this communicative event, student 14 has criticized the interface of the student 13, but student 13 has not answered.

3. Communicative Event Intimidation

> Student 23. "Student 24, your interface sounds inefficient, because there must be an employee monitoring it 24 hours a day."
> Student 24. "Student 23, there are many employees. The employer decides who is going to monitor the interface. Haven't you read my proposal?"
> Student 24 has not defended his interface by means of a democratic and argumentative discourse. His argument is wrong. Besides, he has expressed himself by means of a communicative act with the intention to intimidate the student 23. He has said "Haven't you read my proposal?"

Teacher's Scaffolding in the Generation of Possible Graphic User Interfaces

The teacher promotes the convergent critical thinking in order to evoke students' divergent opinions and subsequent new reflections and ideas. The teacher also fosters the divergent thinking demanding exploration of new alternatives based on the old ones, and criteria establishment. The teacher asks for students engage critically, but creatively on other students' ideas:

"During this phase, besides creating an original interface, you must develop the critical thinking to evaluate and analyze the interface proposals. You must to investigate, inspect, argument, and counter-argument the proposal of a component of your group. Also try to improve others interface proposals in some aspect or to propose a new one, following criteria. The students that had your interfaces criticized must counter-argument and improve their ideas"

Communicative Acts and Events Analysis in the Generation of Possible Graphic User Interfaces after Teacher's Scaffolding

4. Communicative Event Advancement

> Student 1: "The interface navigation occurs in a 3D environment, in which the user is able to control his navigation using the four keyboard keys of direction. The user is only allowed to navigate in four directions? He is allowed to combine the keys to walk in other directions? If the student is only allowed to navigate in four directions he will be not able to rotate, to look above and bellow, and to go diagonally. I think that it constraints to much the interface. If the user wants to test a mobile disposition he will need more flexibility. Another thing, in your interface a picture is shown when the user wants to visualize a room. This is another restriction, because he will only able to see ready houses, he will neither be able to imagine neither a house nor to propose one."
> Student 2: "I believe that these interface's functionalities could be increased. The initial propose was only made for ready houses, but it constrains the interface to much. Your comments really enrich my interface. But it is needed to have in mind that in controlling the directions the user must have a non complex mode. This is easier to learn. I have been thinking, what do you think about to make available a tutorial teaching how to use the application?"

Student 3: “And what about the houses customization? Maybe the user would like to be able to experience different colors on the walls or different textures? What about to move or remove walls? The user could want to make a reform in the house. The user could choose among the three dimensions in order to make this. How the customization will be? I think that text fields couldn’t be used, because the user could have to entry many values to obtain a result. I suggest the use of direct manipulation, thus the user can translate, rotate, delete, or change scale of an object by means of an instantaneous visualization. “

Student 2: “I think that your customization proposal is a good extension to my interface, but I think that it is useful only to houses for sell, it does not include houses for rent. The customization is also ok. I have thought a visual interface, but I haven’t seen a way to implement it. Thank you.“

In this speech event, the ideas have been systematically and reflectively incorporated into the way the students diverge and surpass the initial positions in the group. At event level there has been the communicative event attack followed by the communicative event advancement. The ideas advanced in many directions after some critics. At individual level there have been the communicative acts interpretation, relevance analysis, fluent production and re-directing. In this way, the students converged to diverge causing the knowledge improvement.

5. Communicative Event Attack

Student 2: “There is a requisite non functional in your interface. You guarantee that the user is going to spent less than one minute to learn of your interface. How do you guarantee that? Do you know the user profile? I think you have to restraint a lot the previous user’s knowledge to be able to assure that.”

Student 4: “Well, if your grandmother is not able to turn on the computer, for sure I am not going to think about her, because she is not a representative of the majority. Besides, I can not underestimate the user and make and interface for an idiot person. By the way, my grandmother has MSN. If you want I can send you her e-mail.”

Student 2: “According to my classes about human-computer interface, it is necessary to make clear who is going to use the interface. Its necessary to describe the user profile, even my grandmother could be considered a target audience. “

Student 2 criticizes the Student 4 proposal pointing that an argument presented is not true in general. Student 4 is not able to refute student 2. Student 2 makes clear to student 4 why she is wrong by means of functional criteria. Student 2 performs communicative acts attack and explanation, while the communicative act of student 4 is seen as an inconsistency, although the intention has been a plausible explanation. This communicative event shows that the convergent thinking must be used in a divergent phase to discard non profitable and irrelevant alternatives. So, the group can diverge properly.

6. Communicative Event Rebuttal

Student 2: “I think that your interface is limited.”

Student 3: “What do you mean by limited? In which aspects my interface is limited?”

Student 2: "The search mechanism is restricted."
Student 3: "I don't think so."
Student 2: "Your search mechanism only allows to search by type of construction (house, apartment, and office). What if the user wants to search by site, by value, or by type of negotiation (rental or sale)?
Student 3: "Ok, I agree with you. It is much more interesting for the user the availability of more search options. Thus, he can make a better deal."

At individual level there have been the communicative acts criteria establishment, elaboration, and relevance analysis. Student 2 proposes modifications in student 3's proposal, suggesting a better search in function of the real state context established by the student 3. Student 3 disagrees at the beginning of the discussion, but after he yields to the argument of student 2. In this communicative event the knowledge has been rebutted to a deeper knowledge. This communicative event depicts a transaction where a student elaborates other student's idea. From a critical posture student 2 realized a criteria and a new idea, so student 2 converged to diverge.

7. Communicative Events Attack and Defense

Student 11. "Despite your interface is innovative and interesting, I think it is very complex, implying some technical difficulties during it implementation. "
Student 14. "It does not care if it's difficult to implement. Let's imagine that we have a MIT group do this job."
Student 12. "I don't think that Student 14's interface is not feasible. It is possible to utilize the google earth interface to do this."
Student 11 criticizes the interface of student 14. Student 14 counter-arguments. Student 12 counter-arguments back and also proposes an alternative for implementation. So, there has been the knowledge advancement after critics. The students converged to diverge. At individual level there have been the communicative acts interpretation, justification, and elaboration.

Communicative Acts and Events Analysis in the Consensus about the Best Graphic User Interface before Teacher's Scaffolding

8. Communicative Event Election

Student 5: "Then, I think that all interfaces are good. But, I vote in Student 9's interface."
Student 6: "I vote in Student 5's interface. It is going to be rich if it is refined."
Student 7: "I vote in Student 9's interface. I am sure that we will be able to improve it."

In this communicative event the students simply communicated information. An end user interface has been chosen with no fundament. There is no transitivity and no argument. The majority vote has been contemplated, contradicting the productive online discussion. It has not been given priority to free and ethical critics and argumentation, and the conformism has been not condemned. The speech acts does not indicate an argumentative discourse. The students neither have gone further in their individual visions nor different way of thinking have turned into a mutual agreement. The students have not

been committed with the knowledge advancement; they applied a quick, but inefficient solution for a dilemma resolution. There has been a premature consensus instead of a progression of ideas.

9. Communicative Event Agreement

> Student 14. "Student 12's interface is interesting and it is useful to learn data structure."
> Student 13. "I think that student 12's interface must be refined, there is many things to be improved. "
> Student 17. "I also think that we must choose student 12's interface."
> Student 13. "Let's choose student 12's interface."
> Student 14. "Ok."

In this communicative event, there has been a premature convergence. The student 12's interface has been chosen without the agreement of all the group components, and the argumentation has been poor.

10. Communicative Event Agreement

> Student 19. "In my opinion, the interface of the student 22 has been the best presented, thus it must be chosen. "
> Student 20. "I agree with student 19."
> Student 21. "Despite I haven't thought this before, I also agree with student 19."

The choice has been based in very superficial analysis. There has been a lack of reflection. The students have not gone deep in their arguments.

Teacher's Scaffolding in the Consensus about the Best Graphic User Interface

In this phase the teacher foster again the balance between convergent and divergent thinking in a transactional way, facilitating the productive discourse with the aim to generate improved solutions and reach the best solution:

"During this phase, besides comparing the solutions, elaborate other's ideas, organize the information and search for reinterpretations, examine what is taken as right, weight your decisions and observe and evaluate the course of the ideas, discriminates important and non-important points in a dilemma, elaborate criteria, and if there is a conflict, revise your ideas and literature to find new alternatives and resolve conflicts by reasoning. Make choice, but you must justify your decisions by means of an argumentative discourse"

Communicative Acts and Events Analysis in the Consensus about the Best Graphic User Interface after Teacher's Scaffolding

11. Communicative Event Dialectical Synthesis

> Student 2: "I based myself on our discussions and I made a synopsis describing how the interface must be. But it is my opinion. I suggest that we work on it."
> Student 1: "Thank you for that. I have some comments concerning your synopsis:
> – I disagree when you say that VRML is going to be used. I believe that the ideal is to program a tool to navigation and visualization. Besides OpenGL we could use C++, C#, Java, or other programming language.
> – In the use section, you haven't said that the mouse also serves to look in any direction.

Student 2: "I made another proposal taking into consideration the Student 1 observations".
Student 1: "Student 2, why the knowledge about Browsers is going to be useful in the scope of our application? It is going to be a desktop application. I really do not understand.
Student 2: "At first, I conceived a Web interface. But now that you contemplated another alternative I have been thinking. I reach the conclusion that a Web application is going to be very heavy. I would like that the group discusses the relation cost/benefit in order to reach a decision about it."
Student 1: "I think will not be interesting a Web application, because it requires a lot of user interaction. It will not be efficient to have a Browser as intermediate. The application must be standalone, not depending from other tools. "
Student 8: "I suggest having two variants of this application: a Web application and a stand alone application. Thus, the Web application would be light weigh, containing few interface functionalities. The desktop application would be complete."
Student 2: "Perfect! Great solution! The desktop solution would be available to download at the Web site, in case the user wants more uses."

In this communicative event, has been possible that student 8 achieves a dialectical synthesis. A new knowledge has been constructed in this communicative event. In a dialectical synthesis the knowledge obtained is an extrapolation of the current ideas, being a kind of divergence, but it is also a convergence to a new solution. In this communicative act the students had to pursue other alternative to resolve a conflict. The conflict followed by a dialectical synthesis describes a transactional knowledge building and reflects a successful collaborative learning process, where the knowledge is advanced. The students engaged themselves in a transaction that depicts a joint synthesis that transcends and includes concepts, and agglutinates ideas in a better idea. Concepts have been integrated, pointing a new and important relationship between different perspectives. This communicative event makes explicit a change from divergence to convergence Student 8 treated the others students' ideas as something that could be improved, considering that to develop other's ideas is an aspect essential and basic for the knowledge advancement.

12. Communicative Events Joint Reflection and Joint Exploration

Student 8: "After analysis of your user interface, I don't agree with your user profile."
Student 2: "Why do you say that?"
Student 8: "I suggest we better think about the user profile. In fact, we haven't discussed the possible user classes. In my opinion there are two user classes: The client and the salesman.

- Client: interested in choosing a house for rental or purchase. His most important activities are search for a house, interior navigation, customization, and other previously discussed.
- Salesman: interested in selling or renting a house. His most important activities are preparing the house or possible houses according to a specific client or client class. He would insert pictures, draw objects and visualize the result.

I believe that you will enrich my suggestion with other user classes. What's your opinion? "

Student 2: "I also think that there are only two user classes. I also think that the knowledge required to use the interface is the same to both classes. "

Student 3: "The additional functionalities are going to be available if the user makes a register? I think that some interface functionalities, for example, painting the walls, must only be available for registrant or to potential buyer "

Student 2: "I think that painting the walls must also be available to a person that wants to rent the house. It's good for business if the house could be painted after a color was chosen."

Student 1: "I agree with Student 2. I think that it is a distinguish feature for the real estate firm."

During this communicative event, the group obtained knowledge advancement. The group performed a joint reflection and explorations, where many alternatives have been contemplated from the visualizations of different criteria and a consensus have been reached. At individual level the students performed the communicative acts relevance analysis followed by communicative acts of re-directing. Criteria have been applied to evoke important functionalities of the interface in order to obtain a consensus. The consideration of different criteria is a type of divergent thinking while the consensus is a type of convergent thinking. So, the group diverged in order to not preternaturally converge. The students engaged themselves in a transaction that transcends and includes concepts, advancing the knowledge in a deeper and elaborated knowledge.

13. Communicative Events Rebuttal and Integration Proposal

Student 25. "I don't think that student 26's interface specification is clear. For example, what are the user classes? Are they farmers? I don't think that his interface is easy to use for farmers."

Student 26. "The users are not farmers, but agronomist engineers."

Student 27. "I also think that student 26's interface specification is not clear. I would like to know how the farm will be mapped, how tracing the farm would lead to productivity improvement, what would be shown in student 26's interface, which data could be evaluated, and what king of landscape could be evaluated."

Student 26. "I believe that I have missed some details. Answering your questions, the farm is mapped by means of sensors distributed uniformly on the landscape. The system analyses general conditions of the environment as climate, soil, and other factors. Thus the agronomist engineer can plan his objectives."

Student 55. "After the explanations of student 26, I would like to propose integration between student 26's interface and student 28's interface."

This communicative event intertwines convergent and divergent thinking. The student 26 has been lead to some elaborations of his ideas. His ideas have been rebutted after some critics. The students discussed the interfaces specifications before taking some action in the direction of a consensus.

5.3.3. *Issues of Reliability, Validity, and Generability*

The designed study offered a means of investigating students' transactions and reflections in online discourse during collaborative ill-structured problem solving. Anchored in ill-structured situation, the pre-post case studies provided understanding of a different and new interpretation of productive discussion.

The pre-post case studies were used to support theoretical assumptions held prior to data gathering. Communicative acts and events analysis before teacher's scaffolding corroborated the three main learner obstacles. The students failed to deeply engage the knowledge, failed to generate alternative ideas, and failed to compare different ideas towards an innovative solution. Communicative acts and events analysis after teacher's scaffolding indicated the efficiency of the scaffolding process as well as confirmed the presented perspective of how collective knowledge creation emerges from collaboration and the previously pointed relationships between online dialogue and collaborative knowledge creation.

Concerning the drawbacks of the method, there was no use of outside data sources, for example, questionnaires or interviews, and no use of other methods to validate the findings. However, there were two independent investigators to establish validity through pooled judgment. Besides, by looking at a range of similar cases we had allowed a triangulation of sources of data in order to increase validity and reliability of results as well as strengthened the generability of our findings.

6. Conclusions

The static metacognitive scaffolding process proposed here offers a new viewpoint in collaborative learning. This mediation process consists of a scaffolding to foster collaborative knowledge building in ill-structured problem-solving for innovation. The essence of this facilitation is the ability to alternate between models of rationality, and creativity during argumentation. Cognitive and meta-cognitive processes are mediated by means of interplay between convergent and divergent thinking in a transactional way.

After teacher's scaffolding during an end-user interface specification, qualitative discourse analysis showed some profitable communicative events. In these communicative events, the students deeply engaged the knowledge in respect to generation of alternative ideas, and comparison of different ideas.

The mediation process proposed is able to guide the students to uncertainty, contradiction, and multi-perspectival and dialectical reasoning, promoting the knowledge building cycle presented in this article. The transactional interplay between divergent and convergent thinking is an invitation to enter more deeply in the knowledge, making a creative synthesis of the divergent perspectives. The mediation process presented has potential to imply positively the group to transcend the previous individual knowledge. Emphasis is given to group processes like to discover, improve, explicit, organize, synthesize, and share knowledge. The student is scaffolded by means of a process that points to the dialectic aspects of knowledge in which novel ideas evoke new questions and cause a search for new ideas. New claims incite doubt that triggers renewed attention to the validity of

justifications of claims. Every new idea is concatenated or integrated to prior and future ideas, some of which appears to be contradictory until a synthesis is found.

Transactional balance between the convergent and divergent thinking can allow clarity and logical consistency, encourage learners look deeply into assumptions, points of views, perspectives, and evidence to analyze assumptions, and examine reasons, concepts and consequences. It can help learners to understand the implications of what they discuss online, ask learners to identify cause and effect relationships, and look for relevant and alternative responses.

This work shows that creative knowledge building is a process to do with new ideas generation. However, the exploratory thinking is not sufficient to creativity. A creative idea must be given value by some external criteria and must be critically validated. Exploratory and imaginative processes enable us to develop new relevant and worth ideas if they are aided by reasoning and judgment. Reason and intuition, order and chaos are complementary in mental activities. It is necessary exploratory thinking to generate the new, but critical thinking to judge it.

In order to diverge, learners first must analyze issues, form their personal awareness of issues, generate relationships between concepts, ideas, and information, support, translate, judge, classify, select, match, explain, represent, and demonstrate. Before diverging the students must analyze information by breaking down parts, recognize patterns, investigate cause and affect relationships, form assumptions and identify relationships. Convergent thinking needs to be utilized to check for understanding by asking learners to identify content information or interpret information in a new way.

On the other hand, with the aim to converge, the learners previously must explore different possibilities, variations, and alternative answers or scenarios, and require learners to analyze, synthesize or evaluate knowledge, and project, or predict different outcomes. Divergent questions generally stimulate creativity, and are used. Answers to divergent questions often have a wide variety of acceptability since they are subjective and based on the answers possibility or probability. Divergent thinking needs to be utilized during online discussions to provide opportunities to expose learners to alternative possibilities, and new solutions presented by different learners.

In this work, despite learners have been able to better consider and evaluate different paths, have proposed hypotheses and have raised evidence in support of and against competing hypotheses after the mediation process, it has not been found recursion in the knowledge building process. The knowledge building cycle have not happened repeatedly, in other words, no idea has been rebutted many times. This fact indicates the necessity of the development of dynamic scaffolding to provide a more effective motivation for students deeply engage the knowledge. Dynamic scaffolding process contemplating the productive discourse will be addressed as future work.

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Internetu paremtas diskursas blogai struktūrizuotoms grupinėms naujovių problemoms spręsti

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Šiame straipsnyje aprašoma žodinio kūrybiškumo svarba, pateikiamas išsamus internetinio diskurso aprašas, kuriame išryškinamas studentų konvergentinis ir divergentinis mąstymas naudojant susitarimo ir prieštaravimo dialogą. Kuriant pateiktą išsamų internetinio diskurso apibrėžimą, buvo aptariamas ir vertinamas originalus mokymosi paramos procesas, skirtas tolimesnio bendradarbiavimo žinioms kurti ir netinkamai struktūrizuotoms problemoms spręsti, sutelkiant dėmesį į kūrybingumą ir novatoriškumą. Atlikta kokybinės internetinio diskurso analizė parodė, kad žinių kūrimo proceso gerinimui, žinių progresui svarbi nuolatinė mokytojo parama.